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FIGURES

1. INTRODUCTION

This Attachment was prepared in support of Excelsior Mining Arizona, Inc.’s (Excelsior’s) Underground Injection Control (UIC) Permit application to the United States Environmental Protection Agency (USEPA). Excelsior is applying for an area Class III UIC permit to install a wellfield for in-situ recovery (ISR) of copper at the Gunnison Copper Project (Project), located in Cochise County, Arizona (Figure F-1).

This attachment includes maps and cross sections detailing the geology of the Project. In addition, descriptions of the regional and Project site geology are provided, along with information regarding Excelsior’s geologic model of the Project.

2. REGIONAL GEOLOGIC SETTING

The Project location is within the Mexican Highland section of the Basin and Range physiographic province. The province is characterized by fault-bounded mountains, typically with large intrusive cores, separated by deep basins filled with Tertiary and Quaternary sediments (basin fill).

The Project lies on the eastern edge of the Little Dragoon Mountains (Figure F-2). The Little Dragoon Mountains are an isolated fault-bounded up-thrown block that is characteristic of the Basin and Range province. The ages of the rocks range from 1.4 billion years old (Pinal Group schists) to recent Holocene sediments. The southern portion of the Little Dragoon Mountains consists predominately of the Tertiary Texas Canyon Quartz Monzonite whereas the Pinal Group schists and the Paleozoic sediments that host the regional copper mineralization dominate the northern half.

The oldest rocks in the area, the Pinal Group schists are composed of sandstones, shales and volcanic flows that have been metamorphosed to greenschist-amphibolite facies. The Precambrian Apache Group unconformably overlies the Pinal Group Schists and is composed of conglomerates, shales and quartzite that were subsequently intruded by diabase sills. The Apache Group is then unconformably overlain by the Paleozoic rocks that host the mineralization, including the Bolsa, Abrigo, Martin and Escabrosa Formations. Overlying the mineralized rocks is the Black Prince limestone which is overlain by the Naco Group (Horquilla Limestones, Earp Formation and the Colina Limestone). Basin fill has filled in the valleys.

2.1. Geologic Formations

Cooper and Silver (1964) described the geology of the Dragoon 15-Minute Quadrangle in which the Project will be located. The following formations and descriptions (in their unaltered states) were identified at and near the Project:

2.1.1. Basin Fill

Basin fill (named by Cooper and Silver (1964) as "Quaternary-Tertiary alluvium"): "Conglomerate, sand, and fine-grained lake deposits; unconsolidated to semiconsolidated. Older part equivalent to Gila conglomerate." Basin fill lies unconformably on all the other formations and is made up of at least three parts:

> Older deposits equivalent to the Gila conglomerate: "underlies the intermountain valleys and consists of a thick faulted and gently folded sequence of fanglomerates and lake beds

> . . . ranges from coarse poorly sorted and poorly bedded fanglomerate to fine well-sorted and well-bedded lake deposits. Some parts of the rock are cemented by calcium carbonate, but most of it is poorly consolidated. The sediments are generally coarsest near the present mountains and finest in the centers of the intervening basins”
>
> Pediment gravels: “form a thin unconformable mantle which was spread out on erosional surfaces”
>
> Recent stream deposits: “are along present stream channels cut into all the older rocks.”

2.1.2. Bedrock

Tertiary Texas Canyon quartz monzonite (Ttm and Ttma): “Biotite-quartz monzonite, medium-grained; commonly contains phenocrysts of potassic feldspar an inch or two in length . . . 30 to 35 percent quartz, 30 to 40 percent plagioclase, 25 to 30 percent potassium feldspar, and about 5 percent mica . . . Steep joints that strike northeast are conspicuous throughout . . . forms much of the southeastern half of the Little Dragoon Mountains . . . The most probable time of intrusion is early Tertiary, at the close of the Laramide revolution.”

Pennsylvanian Horquilla limestone (Ph): “Limestone, characteristically blue-gray, medium-bedded, and fossiliferous; thin interbeds of shale throughout; a few sandstone beds in upper part; 30 to 65 feet of red shale at base.” This unit is part of the Naco Group.

Mississippian or Pennsylvanian Black Prince limestone (PMb): “Limestone, pinkish-gray, thin- to thick-bedded: 10 to 30 feet of shale and chert conglomerate at base.”

Mississippian Escabrosa limestone (Me): “Limestone, gray, thick-bedded, commonly crinoidal; about 150 feet of dolomite at base and a few beds of dolomite in middle and upper parts. Chert nodules common.”

Devonian Martin formation (Dm): “Dolomite, gray to tan, fine- to medium-grained, thin-bedded; contains sandy and silty beds in lower half and 15 to 30 feet of reddish-brown shale at top.”

Cambrian Abrigo formation (Ꞓb) is made up of three members:

- Upper member: “Sandy dolomite and dolomitic sandstone; contains few thin quartzite beds. Grades to limestone facies in northwestern part of quadrangle. Total thickness 85 to 155 feet.”
- Middle member: “Limestone, gray, thin-bedded; contains abundant mostly irregular partings of silt and sand, some limy sandstone beds, and numerous intraformational limestone conglomerate beds. Total thickness 175 to 255 feet.”

- Lower member: “Shale, olive, fissile; contains a few thin beds of sandstone and dolomite in lower part, and common gray limestone units in upper part; capped by a tongue of crossbedded quartzite in northwestern part of quadrangle. Total thickness 300 to 475 feet.”

Cambrian Bolsa quartzite (Ꞓb): “Quartzite, white to purple or brown, medium- to coarse-grained, in part pebbly; commonly contains conglomerate at base.” Total thickness 480 feet.

Precambrian Apache Group – Dripping Spring quartzite: “Quartzite, white to brown; contains reddish- to deep purplish-brown shaly beds, 2 to 24 in. thick, irregularly spaced” and “Arkosic quartzite; banded in shades of pink.” Total thickness 193 feet.

Precambrian Apache Group - Pioneer shale: “purple shale or siltstone, which contains scarce interbeds of gray quartzite as much as 2 feet thick, and a basal member of medium- to coarse-grained sandstone or quartzite.” Total thickness 304 feet.

Precambrian Pinal schist: “Schists and slates derived from graywacke, shale, siltstone, and minor small lenses of conglomerate. Contains at least one rhyolite flow, lenses of amphibolite and chlorite schist probably derived from basic volcanic rock, and scarce other rock types of undetermined origin.”

2.1.3. Alteration

Kantor (1977) noted that the mineralization of the deposit (previously known as the I-10 deposit) was located in “Escabrosa, Martin, Abrigo, Bolsa, and Precambrian sediments intruded and metamorphosed by the Texas Canyon Quartz Monzonite. Metamorphism is intense and the calc-silicate assemblages that formed reflect both the original composition of the sediments and distance from the stock. Impure limestones were converted to garnet tactite. Impure dolomites were converted to wollastonite, diopside, tremolite, and actinolite tactites. Shales were converted to biotite hornfels. Clean limestones and dolomites, in general, were marbleized.”

2.2. Surficial Geology

As shown on Figure F-2, the surficial geologic unit at the Project is basin fill, identified as “alluvium” by Cooper and Silver (1964). Bedrock outcrops are present within one-half mile south, southwest, west, and northwest of the Project. Horquilla limestone crops out south of the Project, in Section 6. Texas Canyon quartz monzonite crops out along Interstate 10 beyond the southwest boundary of the Project in Section 36. Outcrops of Horquilla limestone, Black Prince limestone, Escabrosa limestone, Martin formation, Abrigo formation, and Apache Group are located west and northwest of the Project, in Sections 25 and 36.

2.3. Regional Structural Geology

Cooper and Silver (1964) described two major orogenies that deformed rocks in the area. The first occurred during early Precambrian time, when the Pinal schist was isoclinally folded, with the general structural trend oriented toward the northeast. Major intrusive bodies ranging in age from early Precambrian to Tertiary are elongated parallel to this structural trend. The second major orogeny, likely the Laramide, occurred in Late Cretaceous or Early Tertiary time, when rocks older than the Texas Canyon quartz monzonite were folded and thrust faulted. The general trend of the structures that formed during that time is toward the northwest, or nearly perpendicular to the structures that formed during the early Precambrian time.

Cooper and Silver (1964) identified two Laramide-aged structural blocks in the Project area, with the contact between the two blocks oriented northwest-southeast across the Little Dragoon Mountains. The southwest block consists of thrust sheets of Precambrian, Paleozoic and Mesozoic rocks which have overridden the northeast block. The Texas Canyon quartz monzonite intruded the southwest block near the end of the Laramide orogeny. The northeast block is tilted to the northeast and is modified by folds and faults. It includes the concealed Antelope Tank fault, which is located in an area between contrasting fold types. Southwest of this fault, folds are broad and open; northeast of the fault they are closed and locally overturned.

Subsequent to the two orogenies described above, additional faulting and folding occurred during the Tertiary period, leading to the Basin and Range topography observed at present. The northwest-trending Gunnison Hills fault, located approximately two miles east of the Project along the west edge of the Gunnison Hills, was active during this time (Cooper and Silver, 1964).

2.4. Site Specific Geology

The geology of the Project has been investigated extensively by Excelsior. The results of the exploration program have been used to develop a geologic model that provides a three-dimensional representation of the formations, structural orientation, fracture intensity, and mineralization. The geological model, which was created by Excelsior and an independent consultant (Mine Development Associates), is based on 217 drill hole data points in the region totaling 245,509 linear feet, including 122 drill holes immediately in the resource area and another 95 within the Project area. The holes were drilled by either core, RC, or rotary drilling methods. Eight-six of the holes were drilled by Excelsior between 2011-2015. The rest of the drill hole data are historical and were acquired by Excelsior from the purchase of the property assets or from public records. Excelsior also used the Geologic Map of the Dragoon Quadrangle by J.R. Cooper to construct and validate the model.

2.4.1. Basin Fill

The surficial geology of the Project is made up of basin fill (Figure F-2). The isopach map (Figure F-3) data were extracted from Excelsior's geological model and are based on the available drilling data. In the vicinity of the ISR wellfield, the thickness of the basin fill ranges from about 300 to 800 feet.

Approximately 1000' east of the orebody, a bedrock ridge results in thinner basin fill ranging from no fill (at an outcrop of Horquilla limestone just south of the Project boundary as shown on Figure F-2) to approximately 300 feet thick. Farther to the east, as the basin deepens, the basin fill thickness increases to approximately 1300 feet at the Project boundary and approximately1800 feet along the western flank of the Gunnison Hills (Harshbarger, 1973)[1].

2.4.2. Bedrock Geology

A bedrock surface geologic map is provided on Figure F-4. The map was generated from Excelsior's geologic model. Elevation contours for the top of bedrock are shown on Figure F-5.

The basin fill in the Project area is underlain by Paleozoic formations and the Tertiary Texas Canyon quartz monzonite. The western portion includes the Texas Canyon Quartz Monzonite, Escabrosa Limestone, Martin Formation, Abrigo Formation, and Bolsa Quartzite. These formations are highly faulted in the southwestern portion of the Project. Normal faults generally trend east-west and southwest to northeast with at least one fault trending northwest to southeast. Several sub-parallel thrust faults in the same area trend northwest to south east.

Bedrock in the eastern portion of the Project was interpreted by Cooper and Silver (1964) as Paleozoic sedimentary units. Excelsior has mapped the younger sediments as Paleozoic-Mesozoic undivided, as some younger units of the Naco group may be present. Tertiary volcanics have also been identified, based on the drill data that are available.

2.4.3. Geologic Cross Sections

Cross sections A-A', B-B', and C-C' (locations of which are shown on Figure F-4) are provided as Figures F-6, F-7, and F-8. These cross-sections were extracted from the geologic model. Figure F-9 is a published cross section from Cooper and Silver (1964), the location of which is shown on Figure F-2. The east-west trending cross sections show the bedrock ridge that is located east of the wellfield and which is apparent on the bedrock surface contour map (Figure F-4).

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[1] This is a greater thickness than what is shown on Cooper and Silver's cross section O-O' (Figure 3-8). The Harsharger data are based on site-specific data, while the Cooper and Silver cross-section is an interpretation.

The cross sections show that basin fill at the Project is underlain by eastward and northward dipping Paleozoic rocks lying unconformably on Precambrian formations. The Paleozoic and Precambrian rocks were intruded by the Texas Canyon quartz monzonite along the western margin of the Project. The cross sections show several vertical and eastward or southward dipping faults.

2.4.4. Structure and Mineralization

The structural geology and mineralization at the Project have been described by M3 Engineering (M3, 2014 and 2016). Structural trends at the regional scale include beds which strike northwest and dip 20-40 degrees to the northeast, and a large number of northeast-striking normal faults.

The strong regional trend of northeast-striking normal faults is overprinted by an abundance of north-northwest striking reverse faults, joint sets, and normal faults which range in dip from 35 degrees east-northeast (sub-parallel to bedding) to 75 degrees east-northeast. The reverse faults strike parallel to the long axis of the ore deposit and control alteration and mineralization.

Late stage east-west striking vertical faults at the north end of the deposit contain local zones of high grade copper oxide mineralization. Porphyritic quartz monzonite intrusions occur along the western margin of the mineralization.

M3 (2014) provided the following detailed description of the relationship between mineralization and the structure of the Project, which they sometimes refer to as the "North Star" deposit:

> *The mineralized Paleozoic host rocks . . . strike approximately north-northwest and dip 20^o to 45^o towards the east. . . . faults include "Northeaster" (N 10^o to 30^o E striking with 70^o to 75^o dip to the SE), "Easter" (N 60^o E to S 60^o E striking faults dipping 30^o to 50^o S and higher angle reverse faults dipping 75^o S) and "Northwester" orientations (N 15^o W strike with steep E or W dip). Only minor displacements are thought to have occurred in the North Star area; however, numerous sheared and brecciated faults generally filled with* [Copper] *Cu oxide mineralization cut through the deposit.*
>
> *The Paleozoic host rocks have been intruded by the Texas Canyon quartz monzonite along the western margin of the deposit. The intrusion has formed wide zones of calc-silicate and hornfels alteration as well as extensive low-grade copper sulfide mineralization within the Paleozoic rocks . . . The important mineralized host rocks include the Abrigo and Martin Formations and to a lesser extent the Horquilla Limestone and the lower parts of the Escabrosa Limestone. Mineralization is also found in the Bolsa Quartzite and Precambrian basement rocks.*
>
> *Copper oxide mineralization occurs in the calc-silicate skarns as fracture coatings and vein fillings in the form of chrysocolla and/or malachite. The mineralization extends over a strike length of 9,800 feet.*

Copper sulfide mineralization has formed preferentially in the proximal (higher metamorphic grade) skarn facies, particularly along stratigraphic units such as the Abrigo and Martin Formations and within structurally complex zones.

Regarding the morphology of the oxide mineralization, M3 (2014) wrote:

The morphology of the oxide mineralization at North Star is predominately a large flat blanket presumably hugging a paleo-water table. . . . The mineralization is fairly uniform in distribution; however, there are some large higher grade 1% Cu pods within the overall mineralized shell of oxidized Cu mineralization.

2.5. Geological Modeling

Excelsior's geological model is based on 217 drill hole data points in the region totaling 245,509 feet, with 95 drill holes within the Project area. The data collected to generate the models are summarized below (M3, 2014 and 2016).

2.5.1. <u>Data Collection</u>

2.5.1.1. Structural Logging

As a part of the general logging process for each corehole that was drilled around the Project, Excelsior logged the mineralogy and structure types (fault, shear, breccias, etc.), and measured the angle of the structure to the core axis. Excelsior's structural logging of the core helped validate the geophysical logs (Section 2.5.1.3) and was used to determine orientation of structures through holes where no geophysical data were obtained.

2.5.1.2. Fracture Intensity

Fracture Intensity is defined as the relative brokenness/permeability of the rock. For each drill hole, Excelsior logged fracture intensity based on a scale of 1 to 5, with a value of 1 assigned to rock that was less than 5% broken, and a value of 5 assigned to rock that was more than 80% broken. The definition of "broken" was based on pieces of core which were measured as 4" or less in length. Examples of fracture intensities are shown on Figure F-10.

2.5.1.3. Downhole Geophysics

Excelsior conducted drill hole geophysical surveys, including caliper, sonic, temperature, and acoustic televiewer logs, to identify and interpret structures. In the boreholes for hydrology study wells (Attachment N-2), the acoustic borehole televiewer images were used to log fracture intensity.

2.5.1.4. Fracture Mapping of Assay Intervals

For every assay interval, Excelsior logged the abundance of fractures in the core. The number of fractures per assay interval (typically ten feet, except at formation boundaries) were logged for the following categories of fractures:

- Quantity of Mineralized Open Fractures per Assay Sample
- Quantity of Mineralized Closed Fractures per Assay Sample
- Quantity of Non-Mineralized Open Fractures per Assay Sample
- Quantity of Non-Mineralized Closed Fractures per Assay Sample

2.5.2. Model Results

Key findings from Excelsior's data collection efforts were described in the Pre-Feasibility Study (M3, 2014 and 2016). They are summarized below.

2.5.2.1. Structural Orientation

The deposit is dominated by north-northwest striking faults and fractures (Figure F-11) that dip from moderate to steep angles (M3, 2016). The moderately dipping features are sub-parallel to bedding and are the most abundant. Steeply dipping features represent reverse faults which displace the beds considerably throughout the deposit, causing repetition in stratigraphic section. Subsets of northeast and east-west striking features occur in distinct regions of the deposit, representing local faults which displace bedding.

2.5.2.2. Relationship Between Structure and Mineralization

Excelsior's examination of the core has shown that much of the copper oxide mineralization occurs on or proximal to fractures in the rock. Highly-fractured zones are typically enriched in chrysocolla, malachite, and tenorite (M3, 2014). Figure F-12 is a plot of average copper grade (% total copper) versus fracture intensity. A clear relationship is observed between copper grade and increasing fracture intensity.

2.5.2.3. Three-Dimensional Structural Model

Excelsior constructed a 3-D Wireframe Structural Model. The model consists of three dimensional volumes which encapsulate significant structurally-affected zones in the deposit. Their spatial locations and orientations were defined by the structural analysis (Section 2.5.2.1). To be considered significant for the purposes of the model, the zones were required to have a minimum thickness of 30 feet and an average fracture intensity value of 3 or higher above. The outlines of the shapes were wireframed and subsequently used to triangulate volumes using Surpac software.

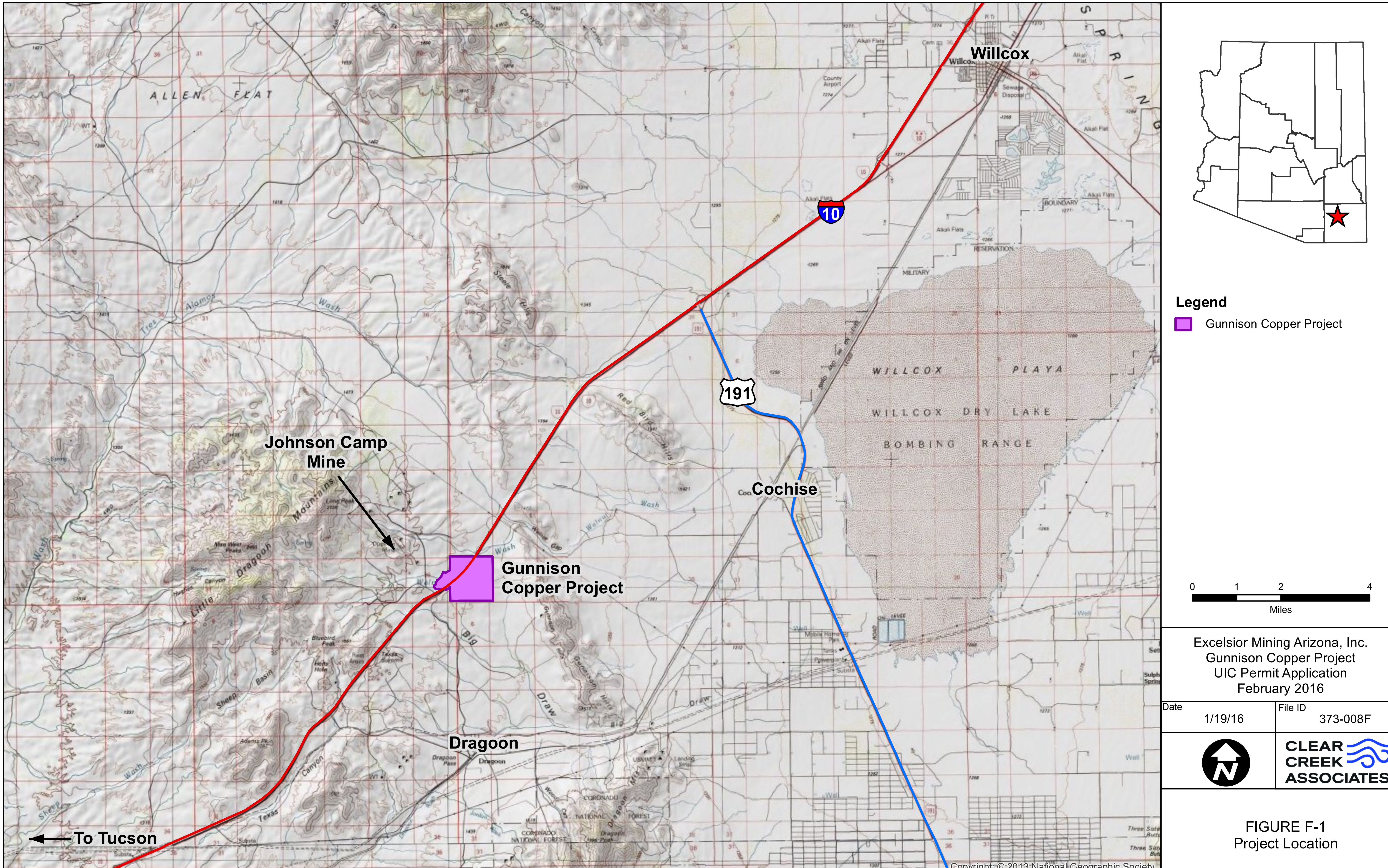
Because the structurally affected zones captured in the model also represent permeability in the deposit, the model is has been used by Excelsior for hydrological planning, drilling, and testing in recent drilling campaigns. Structures that were also important for geological and metallurgical studies were targeted and successfully drilled intersected. Excelsior has updated the model using additional logging and geophysical data from each subsequent drilling program.

2.5.2.4. Fracture-Intensity Model

A fracture-intensity model was created as a three-dimensional representation of the deposit. It is comprised of 50 foot by 100 foot by 25 foot individual blocks. Each block contains a unique fracture intensity value.

The wireframes discussed in Section 2.5.2.3 were used as domains to code the fracture-intensity intervals in the project database to the structural block model. Fracture-intensity intervals lying outside of the structural domains were also assigned a code, leading to a total of 3,485 coded fracture-intensity intervals in the database, 26% of the intervals inside of the solids and the remainder outside. The intervals inside and outside of the structural domains have length-weighted mean fracture intensity values of 3.4 and 2.3, respectively.

The coded fracture-intensity values were composited to 25-foot lengths for use in inverse-distance-to-the-fifth-power interpolations of the fracture intensity into the resource-model blocks. All composites coded to the 61 structural domains were used for the interpolation of values into each of the structural domains coded into the model, and outside-domain composites were used to estimate the values in the remainder of the model. The inside-domain estimations used one of eight search-ellipse orientations to match the average strike and dip of each modeled structural domain. Fracture intensity values of the Paleozoic sedimentary units and Precambrian rocks outside of the structural domains were estimated using an ellipse that is consistent with the average strike and dip of the sedimentary units, while the Texas Canyon Quartz Monzonite was estimated using an isotropic search ellipse (M3, 2016).



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File ID 373-008F

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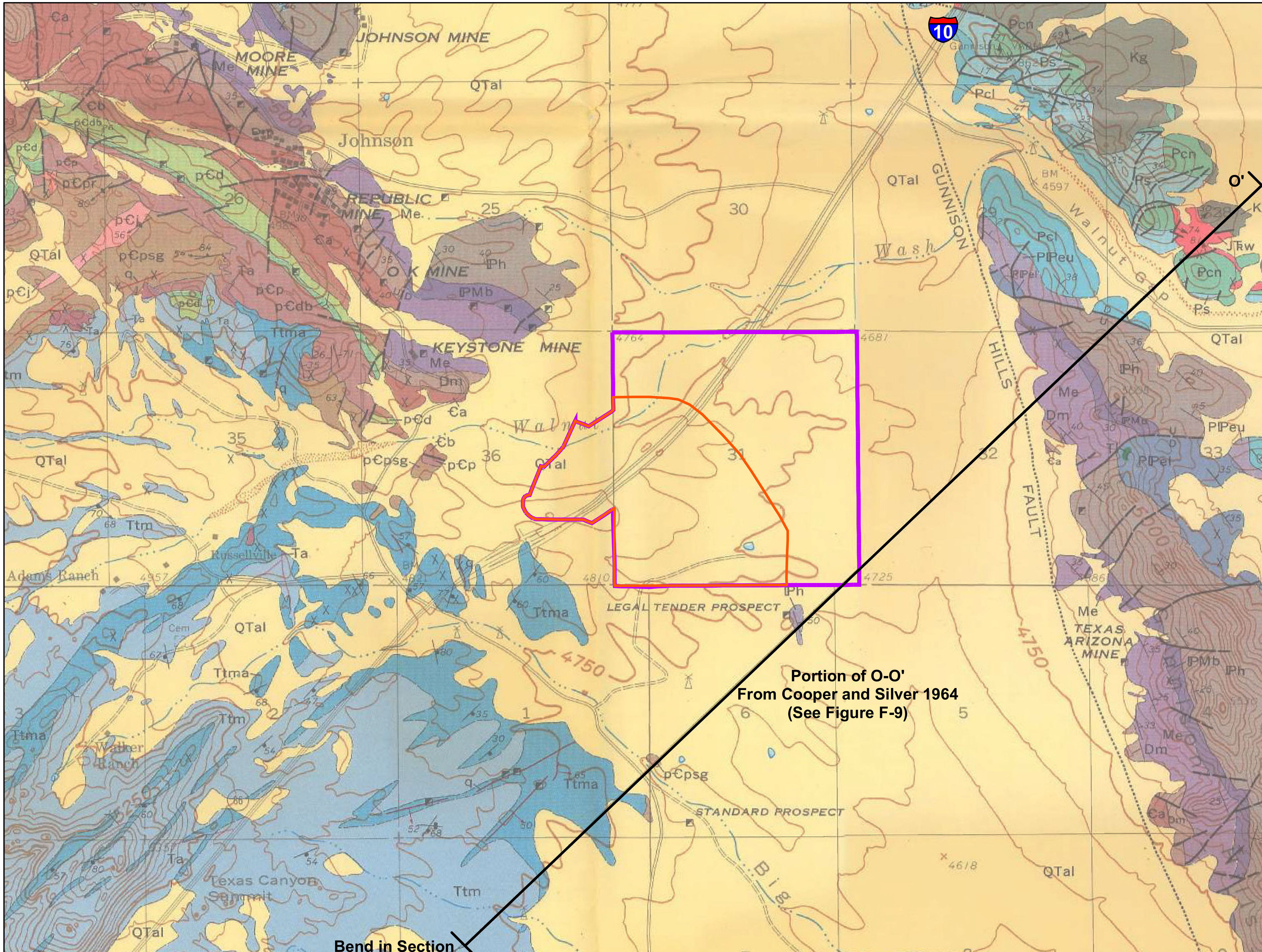
FIGURE F-1
Project Location



Legend

- Gunnison Copper Project
- Area of Review
- QTal - Quaternary Alluvium (Basin Fill)
- Ttm - Texas Canyon Quartz Monzonite
- Ttma - Texas Canyon Quartz Monzonite (altered phase)
- JTrw - Walnut Gap Volcanics
- Pcn - Concha Limestone
- Ps - Scherrer Formation
- Pcl - Colina Limestone
- IPpe - Earp Formation (IPpeu, IPpel)
- IPh - Horquilla Limestone
- IPmb - Black Prince Limestone
- Me - Escabrosa Limestone
- Dm - Martin Formation
- Ca - Abrigo
- Cb - Bolsa Quartzite
- pCd - Dripping Springs Quartzite (Apache Group)
- pCp - Pioneer Shale (Apache Group)
- pCpsg - Pinal Schist

Geology reprinted from Cooper and Silver (1964)

0 1,000 2,000 4,000
Feet

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FIGURE F-2
Geologic Map

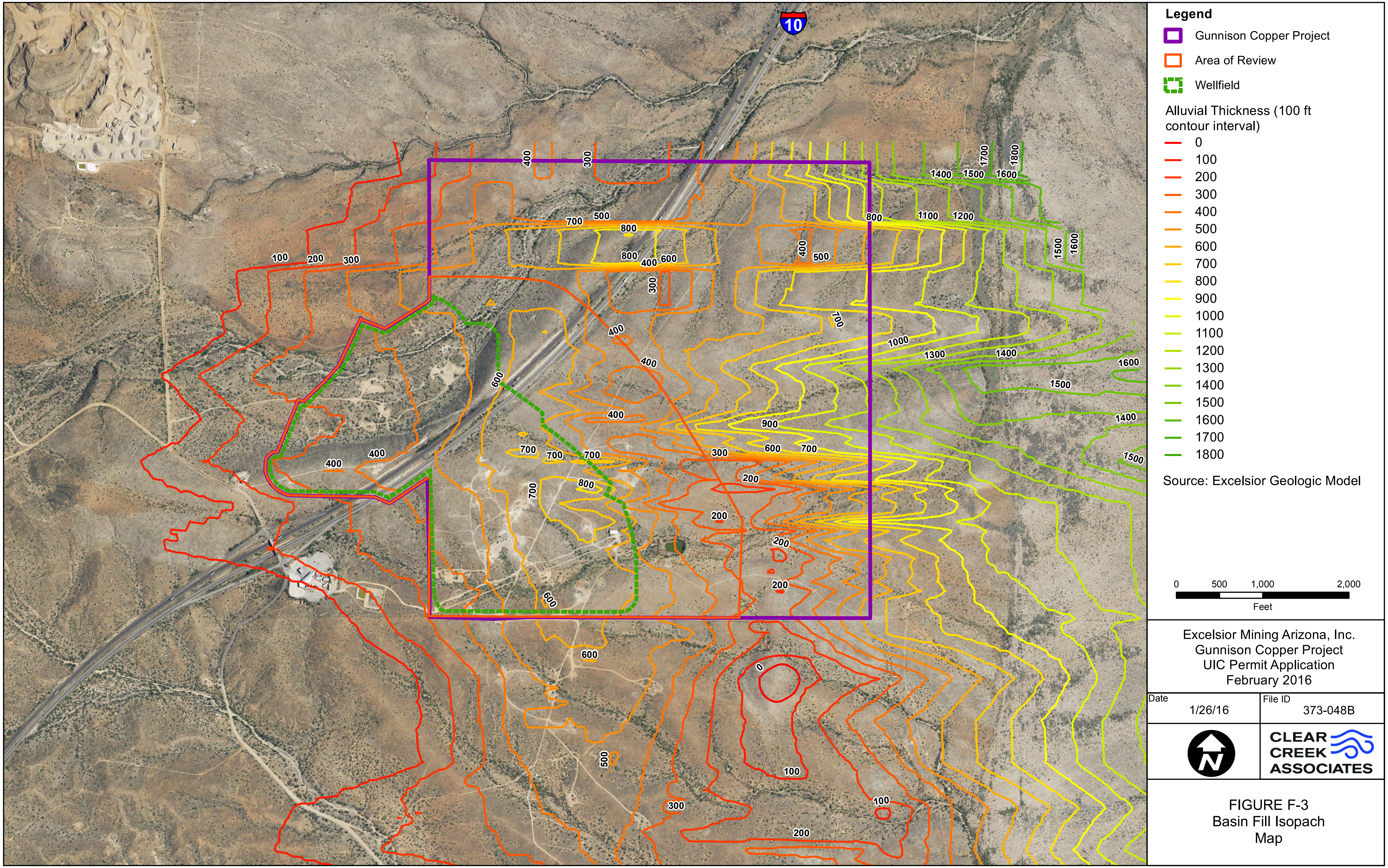

FIGURE F-3
Basin Fill Isopach Map

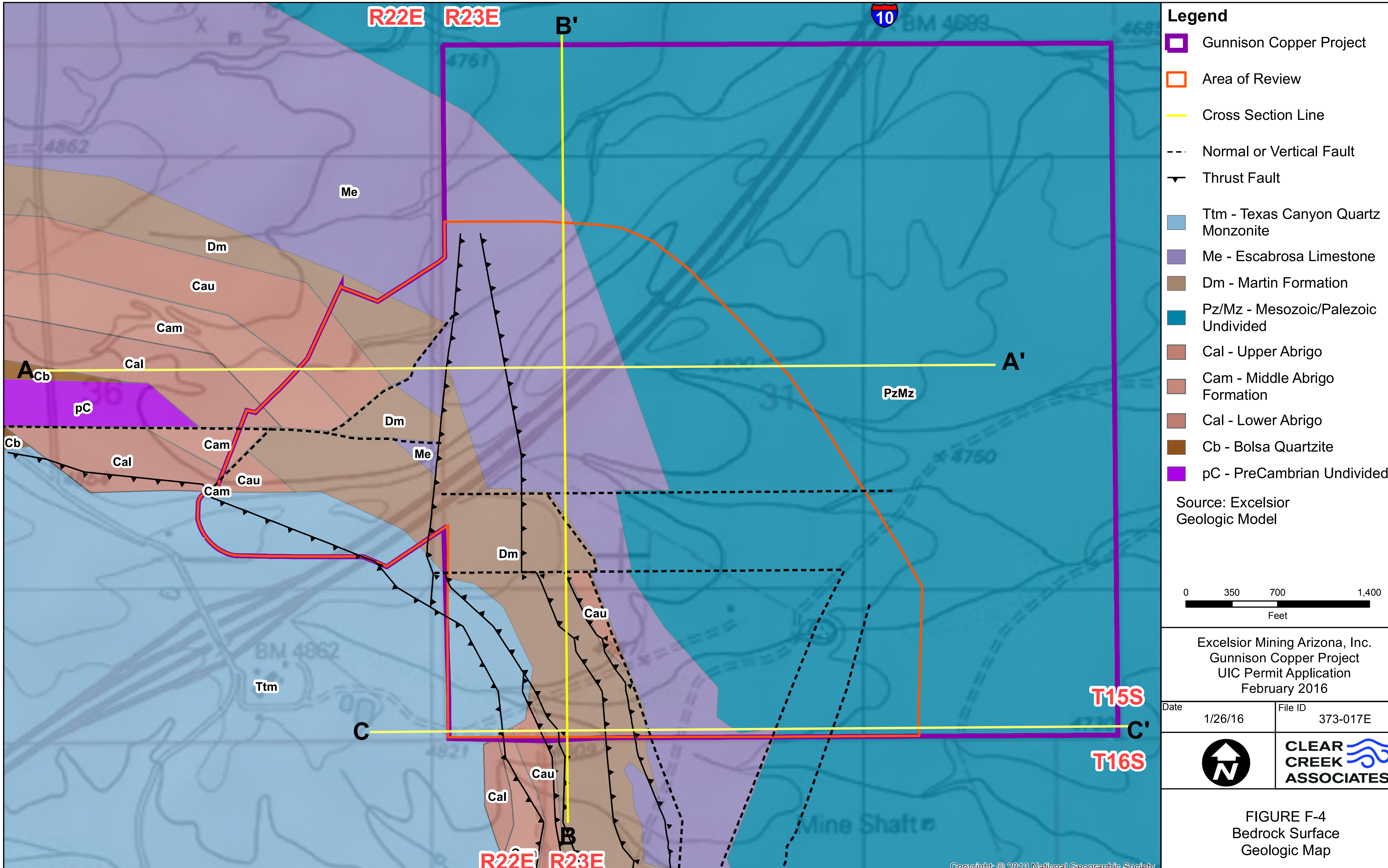

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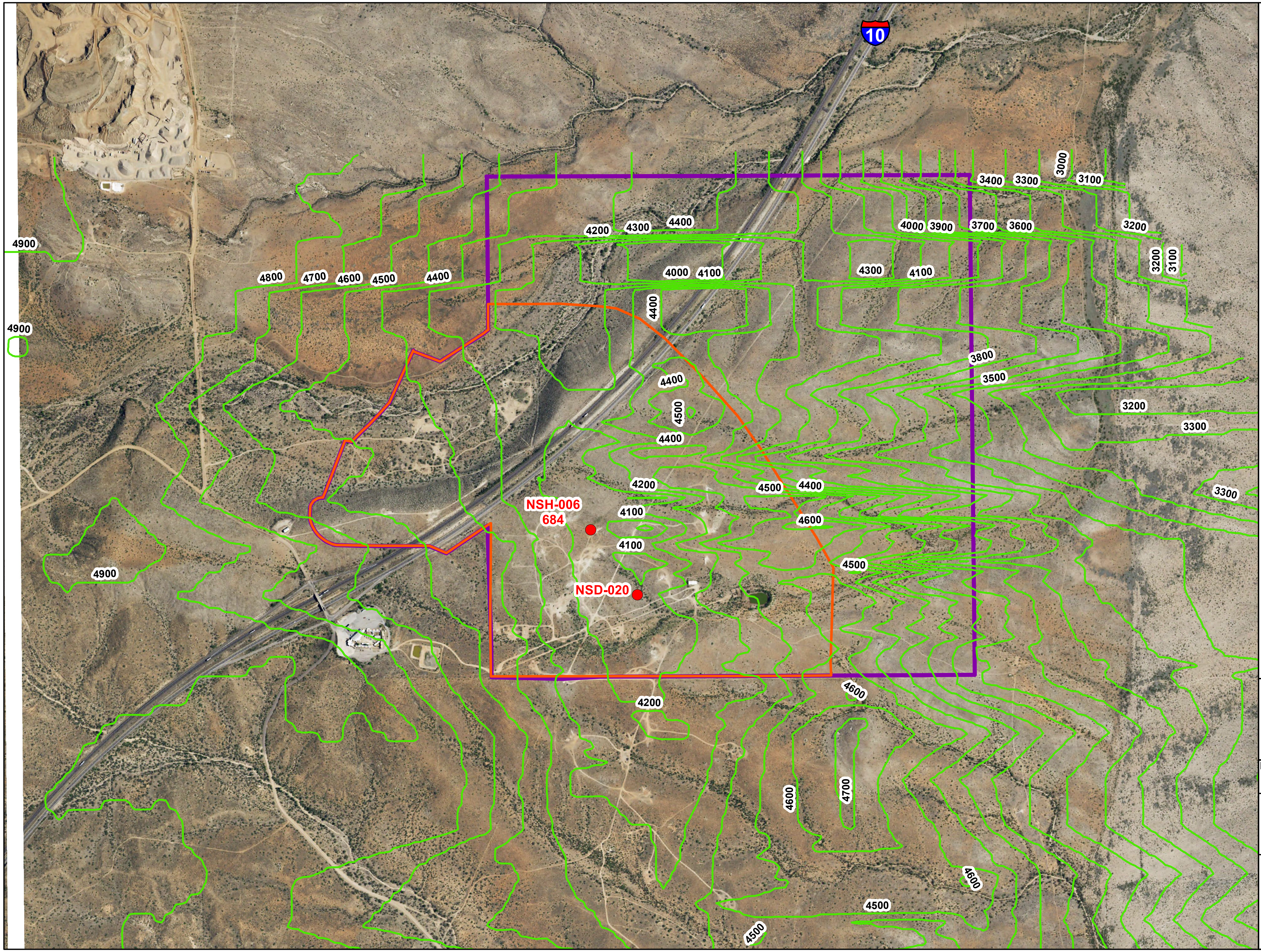
FIGURE F-4
Bedrock Surface
Geologic Map



Legend

- Gunnison Copper Project
- Area of Review
- Bedrock Surface Elevation Contour (100 ft interval)
- Well with Saturated Basin Fill (showing bedrock depth where known)

Source:
Excelsior Geologic Model

0 500 1,000 2,000
Feet

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FIGURE F-5
Bedrock Elevation Contours

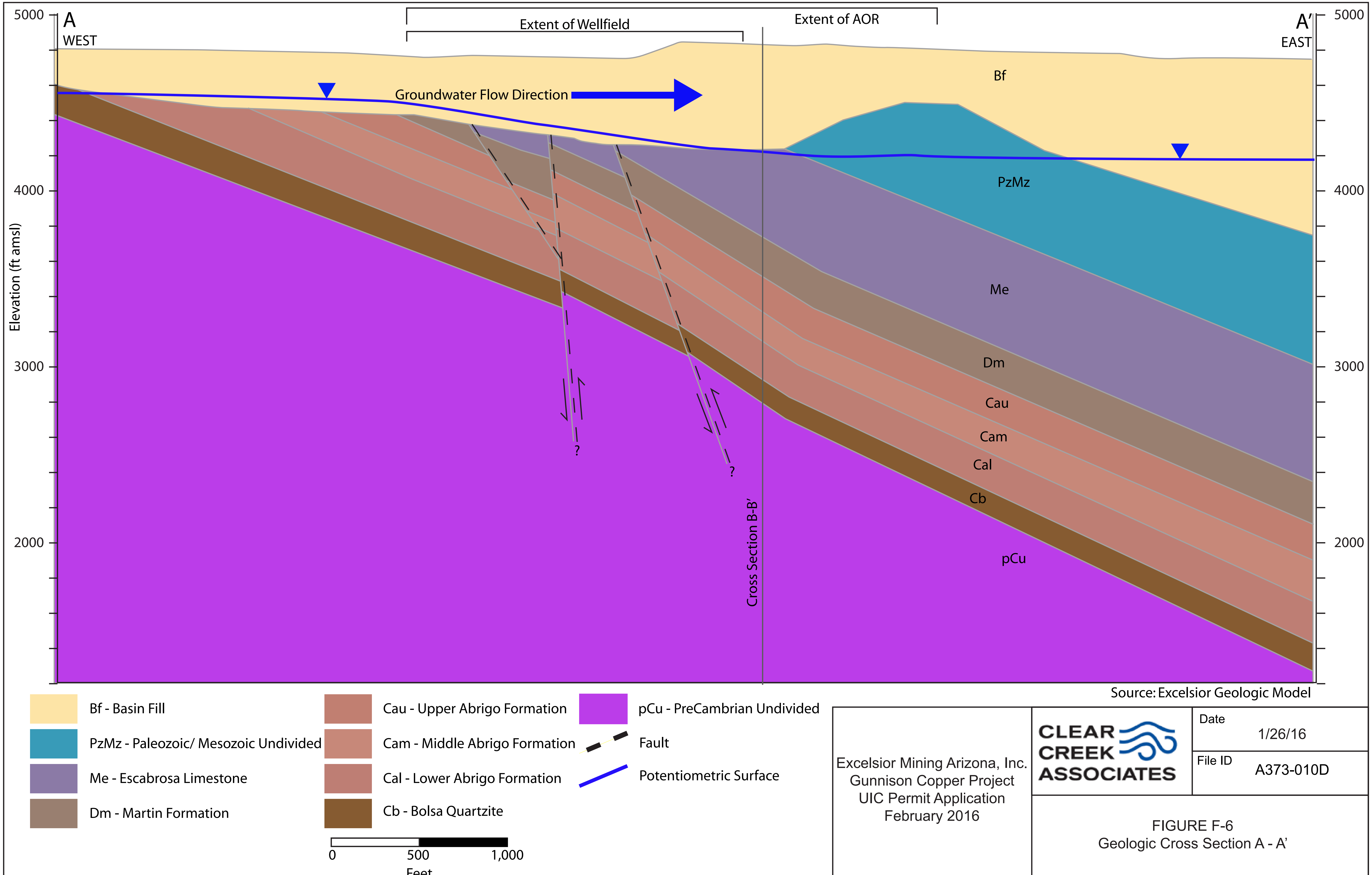

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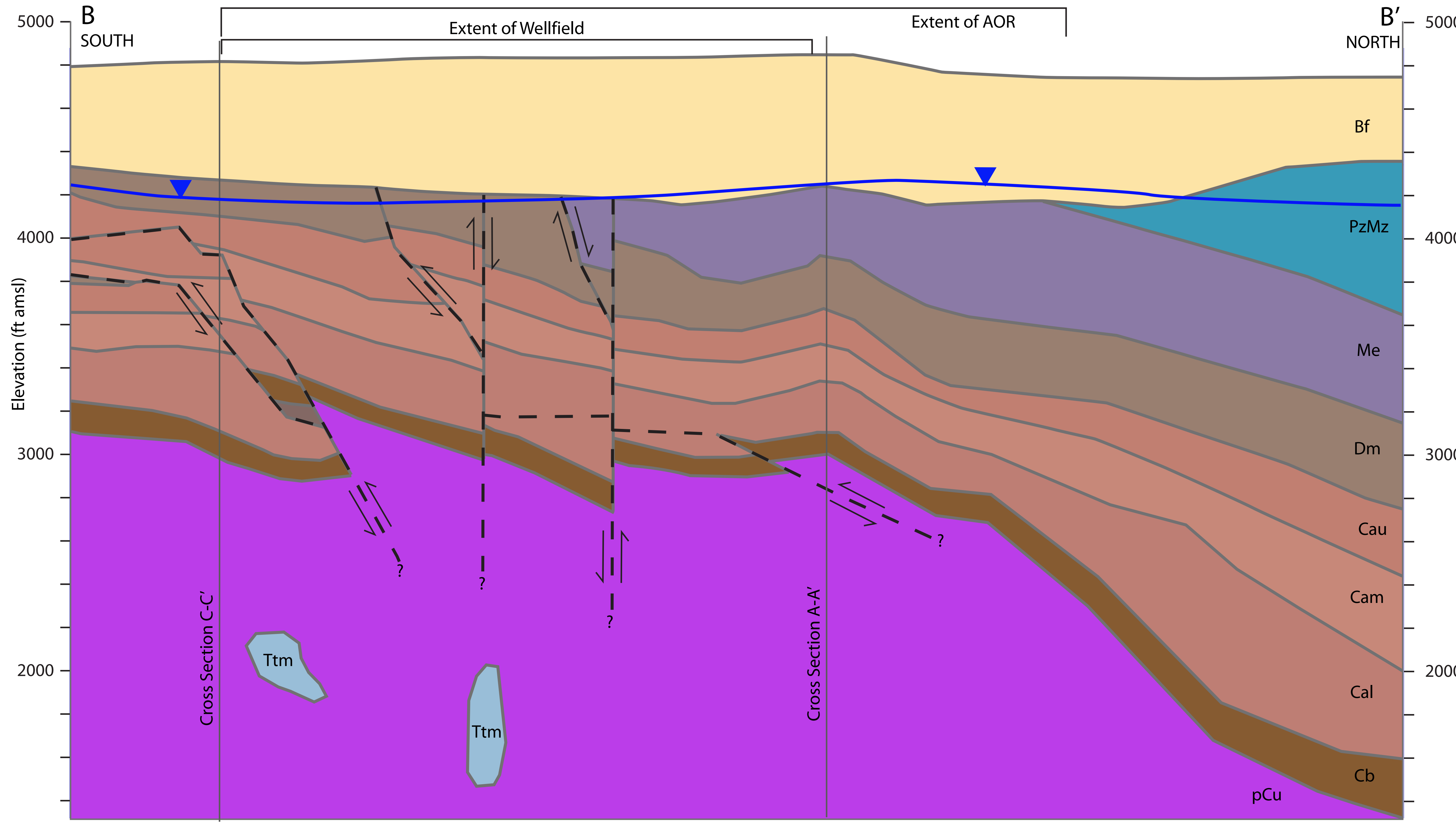
FIGURE F-6
Geologic Cross Section A - A'



Source: Excelsior Geologic Model

Bf - Basin Fill	Cau - Upper Abrigo Formation
Ttm - Texas Canyon Quartz Monzonite	Cam - Middle Abrigo Formation
PzMz - Paleozoic/ Mesozoic Undivided	Cal - Lower Abrigo Formation
Me - Escabrosa Limestone	Cb - Bolsa Quartzite
Dm - Martin Formation	pCu - PreCambrian Undivided

Fault

Potentiometric Surface

0 500 1,000
Feet

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FIGURE F-7
Geologic Cross Section B-B'

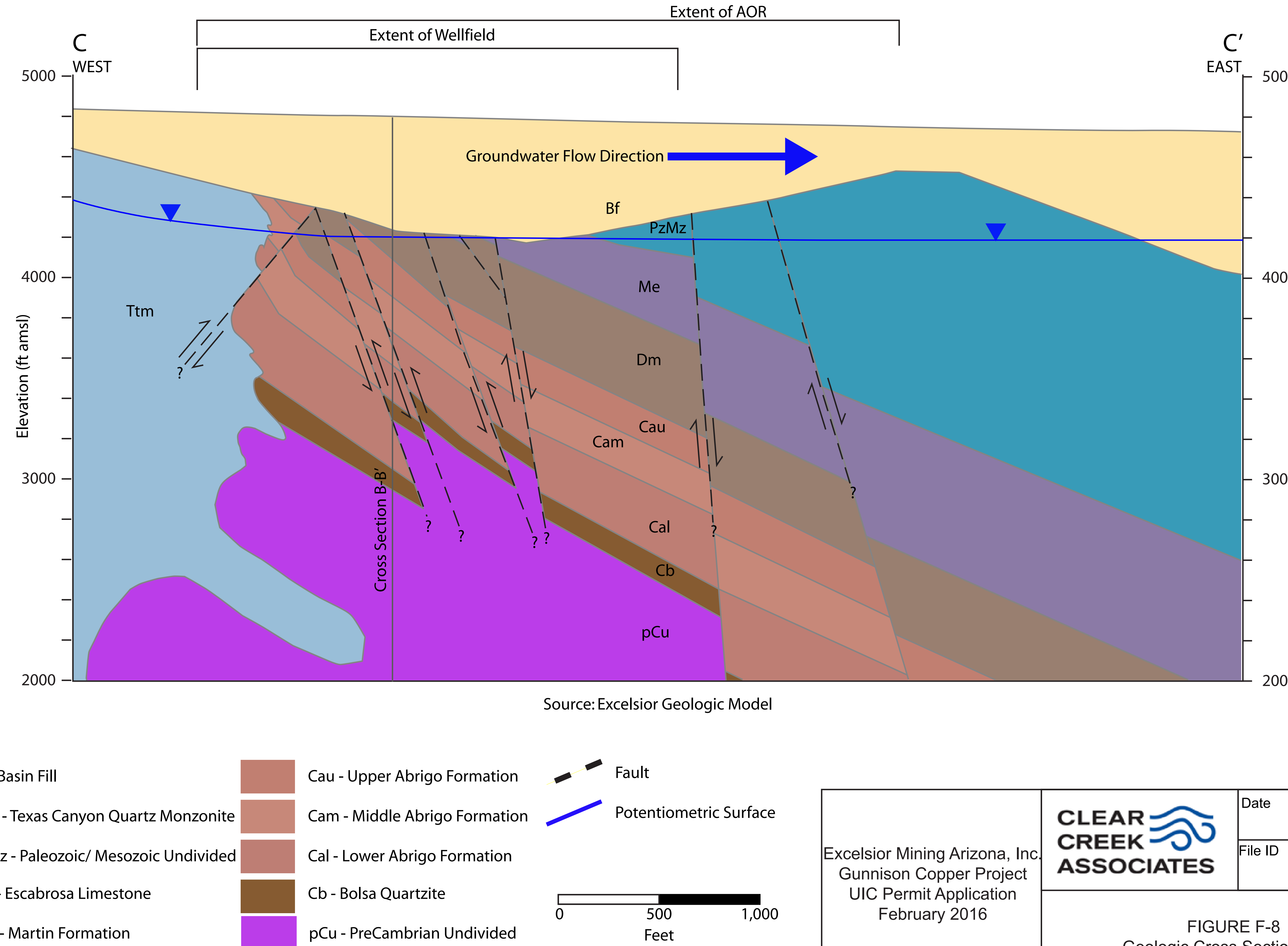

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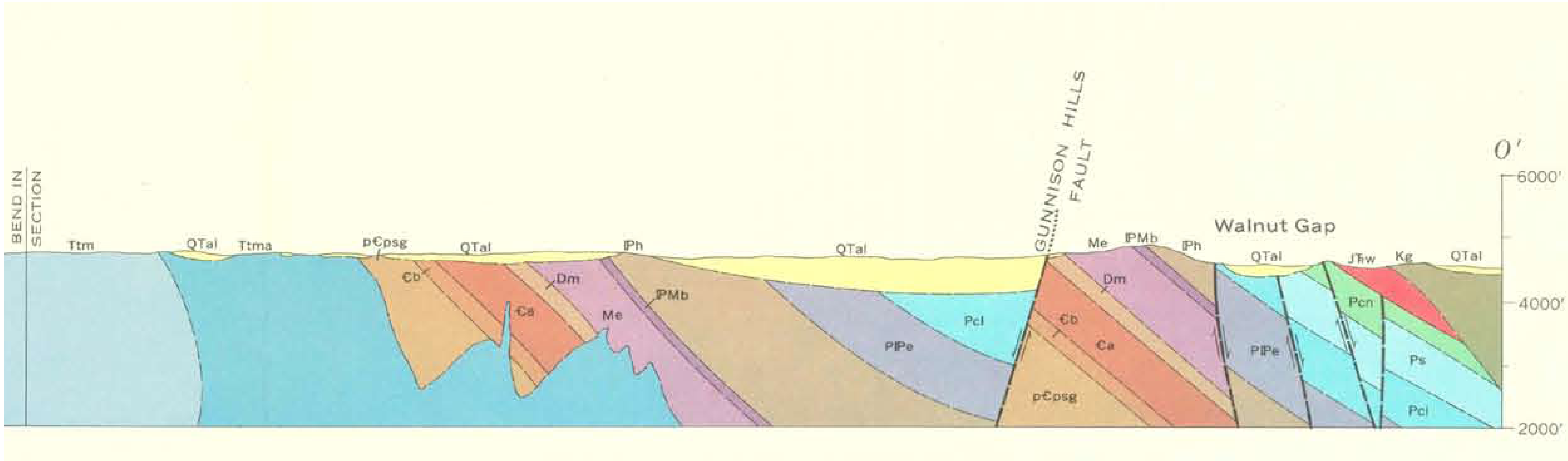
FIGURE F-8
Geologic Cross Section C - C'



Source: Taken from Silver and Cooper (1964)

0 2000 4000

Feet

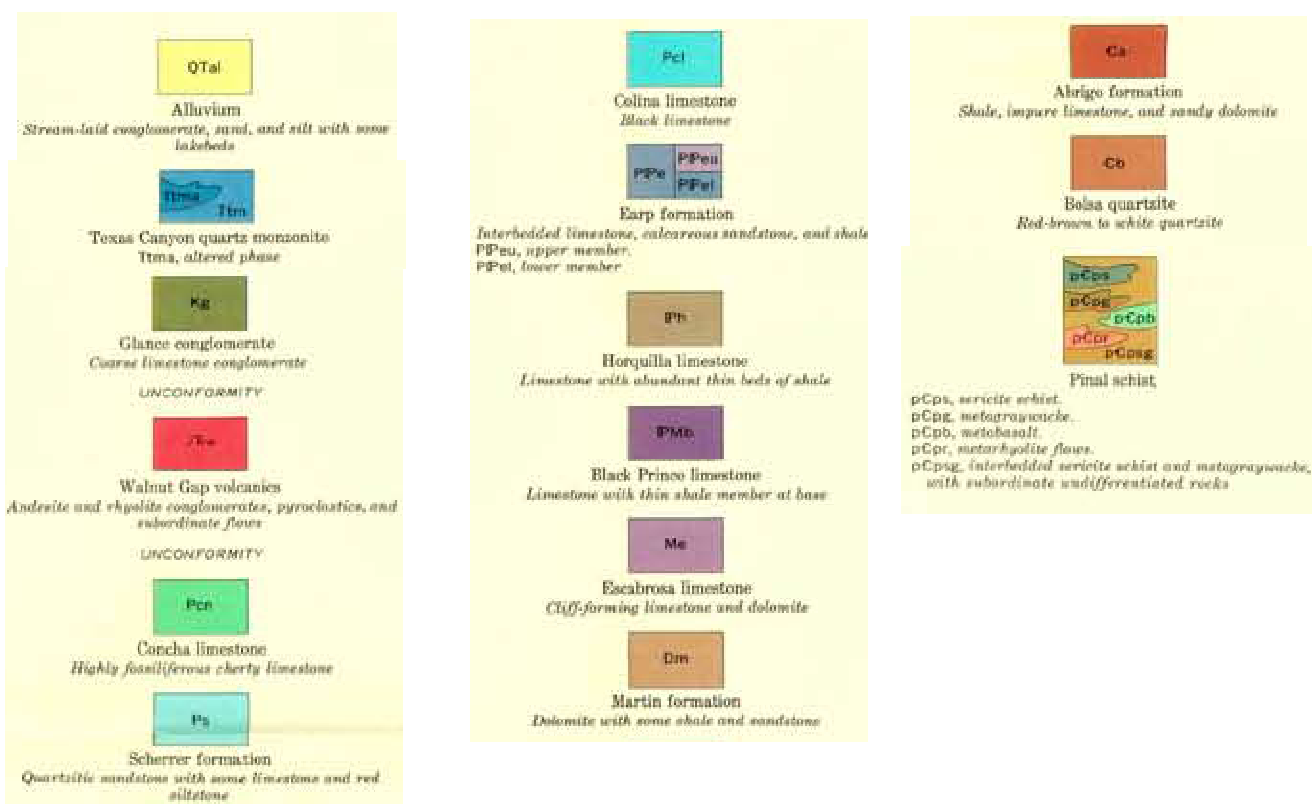


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FIGURE F-9
Portion of Cross Section O-O'
from Cooper and Silver (1964)

Abrigo Examples

Intensity = 5

Intensity = 4

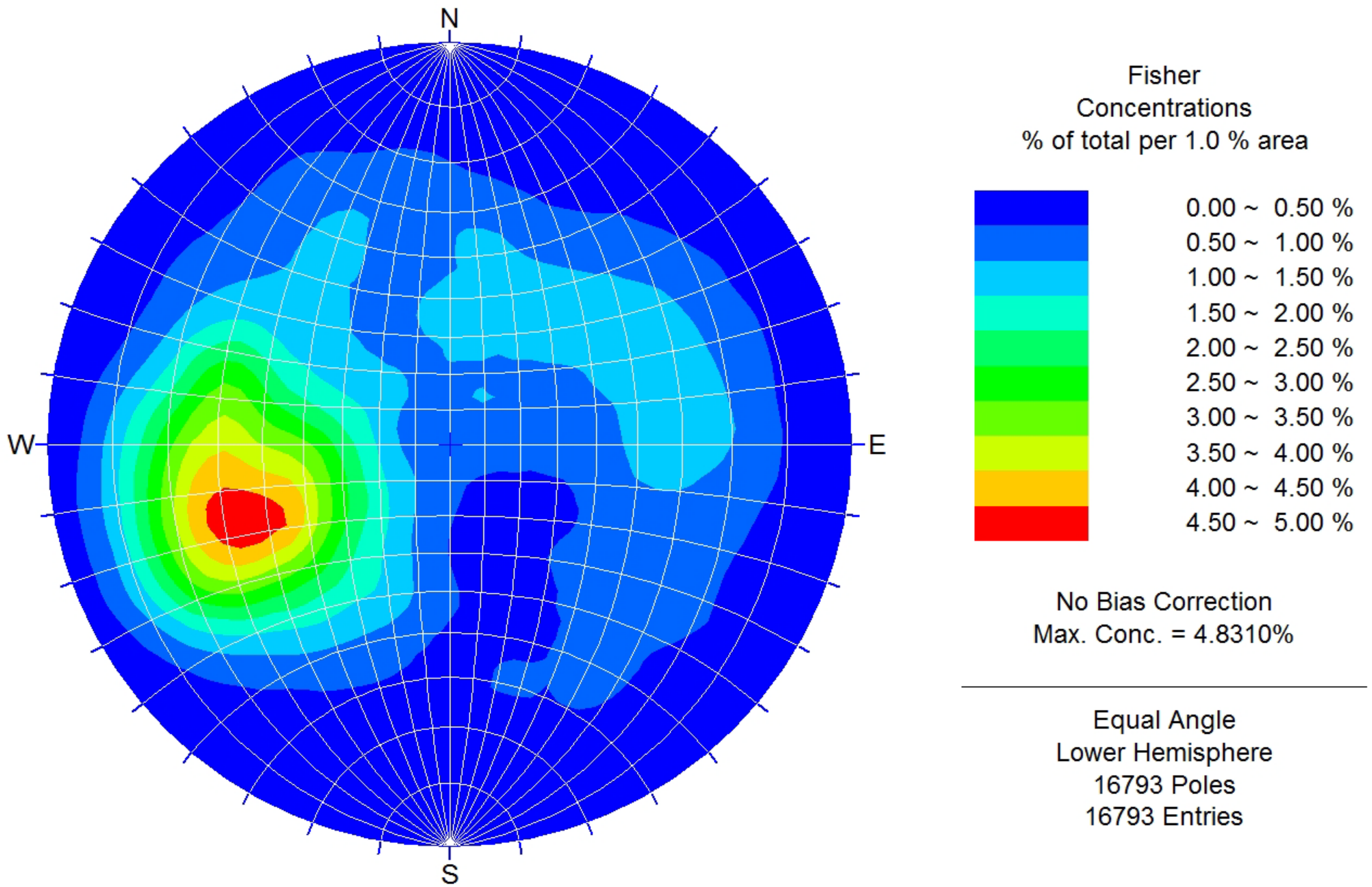
Intensity = 3

Intensity = 2

Intensity = 1

Source M3 (2014)

Excelsior Mining, Inc. Gunnison Copper Project UIC Permit Application February 2016	CLEAR CREEK ASSOCIATES	File ID A373-016A Date 1/26/16
	FIGURE F-10 Fracture Intensity in Cores from the Abrigo Formation	



Source: Bickel (2013)

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FIGURE F-11
Contour Plot of Pole to Dip
for Structural Features
Excluding Bedding Orientations

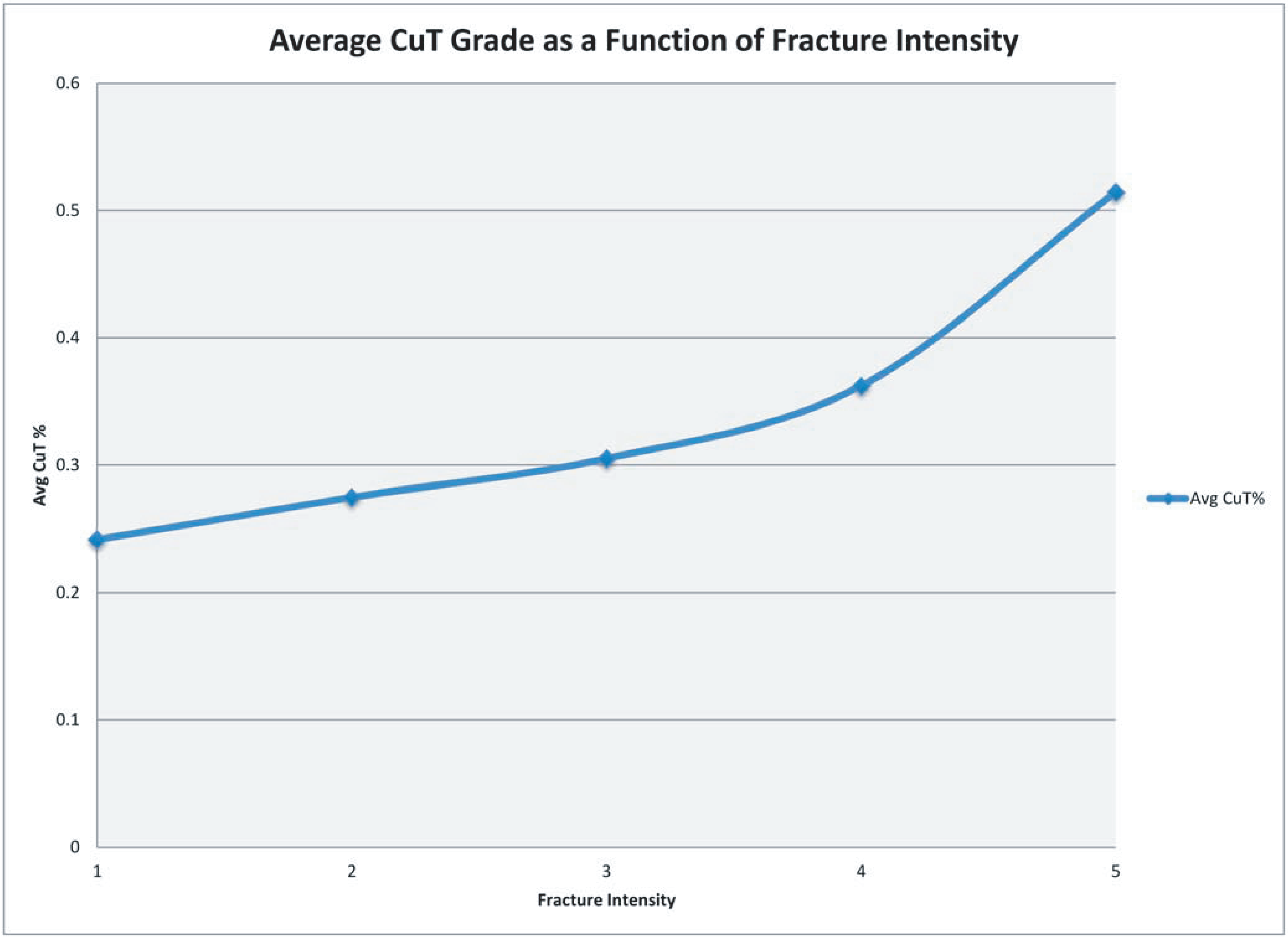

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	FIGURE F-12 Correlation between Fracture Intensity and Total Copper Grade	